



NASA GEOS Composition Forecast system: “GEOS-CF”

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NASA Global Modeling and Assimilation Office (GMAO)

In collaboration with:

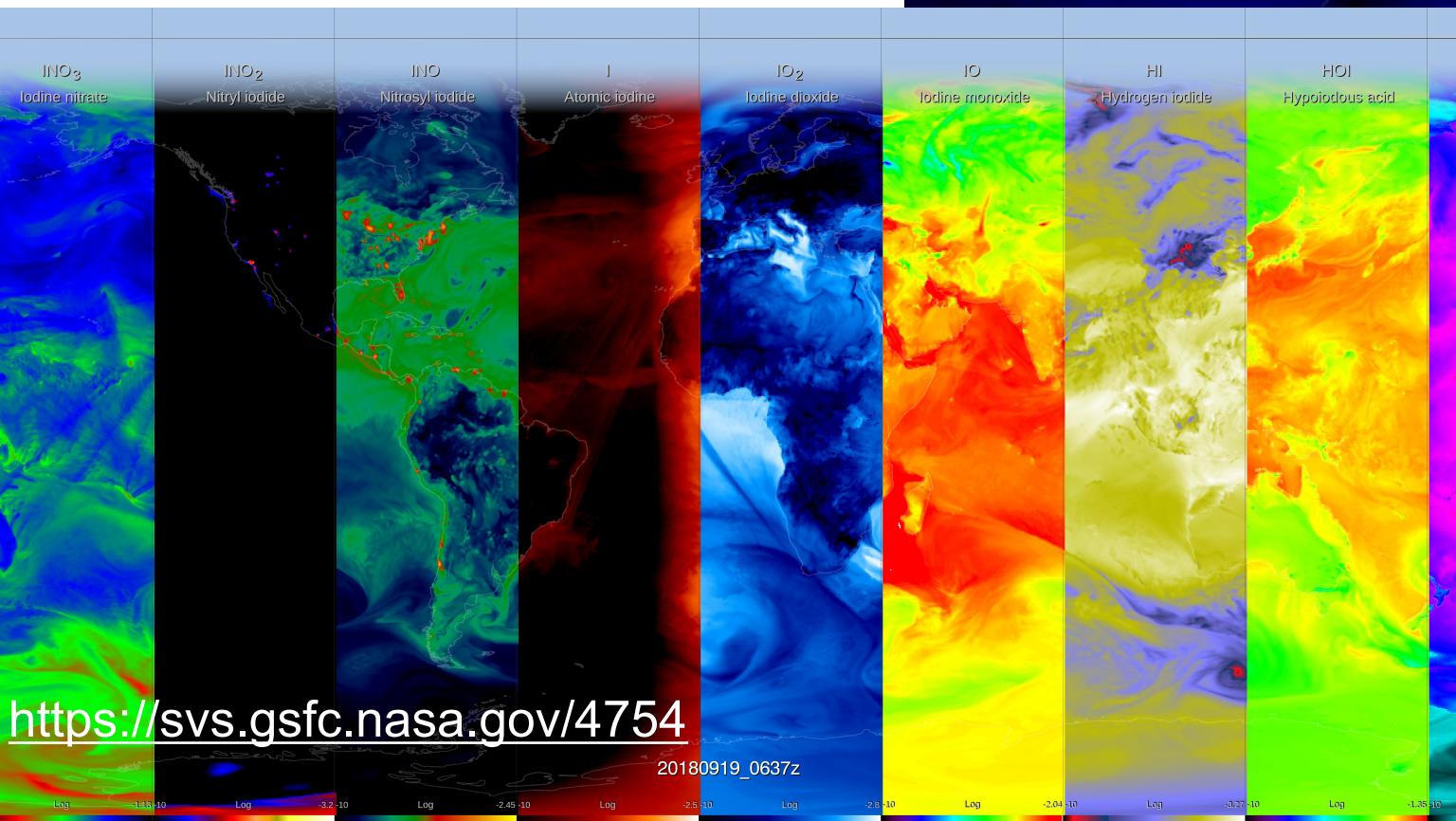
NASA GMAO: Christoph Keller, Pamela Wales, Larry Coy, Kris Wargan, Callum Wayman, Lesley Ott, Steven Pawson

Atmospheric Chemistry and Dynamics Lab: Bryan Duncan, Sarah Strode, Junhua Liu, Julie Nicely, Dan Anderson, Eric Fleming

15 February 2022



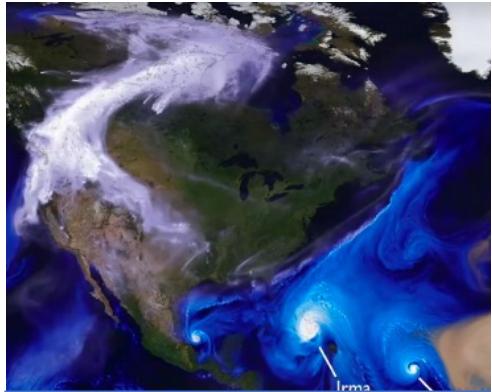
GEOS - CF



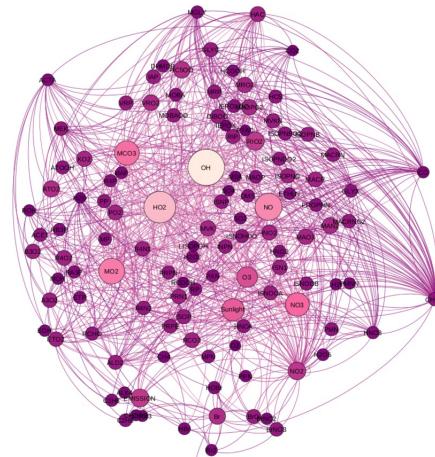
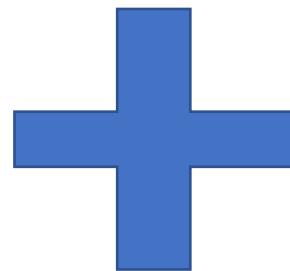
<https://svs.gsfc.nasa.gov/4764>

Global historical model
estimates and daily 5-day
forecasts of major air
pollutants like Ozone & PM_{2.5}

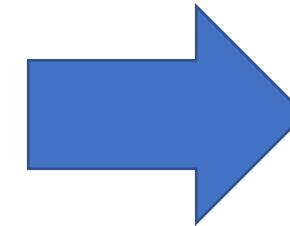
GEOS Composition Forecast



GEOS weather
forecasting



GEOS-Chem

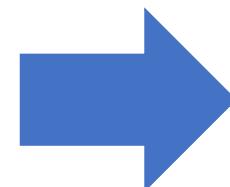
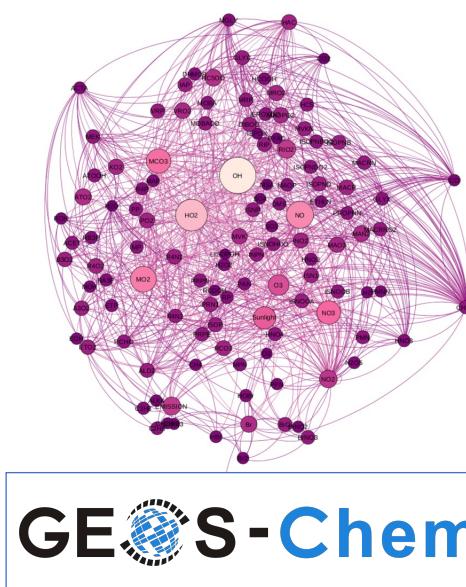
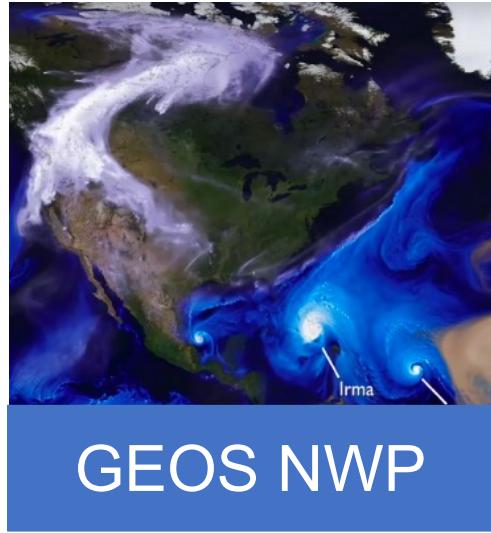


GEOS - CF

Version 12
Tropospheric and Stratospheric chemistry

- 250 Chemical Species
- 725 Chemical Reactions

Daily composition forecast



GEOS - CF

One 5-day forecast per day

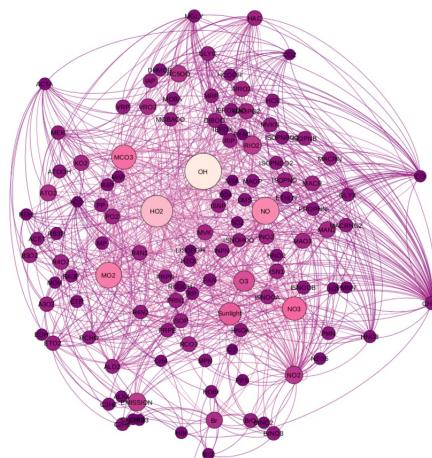
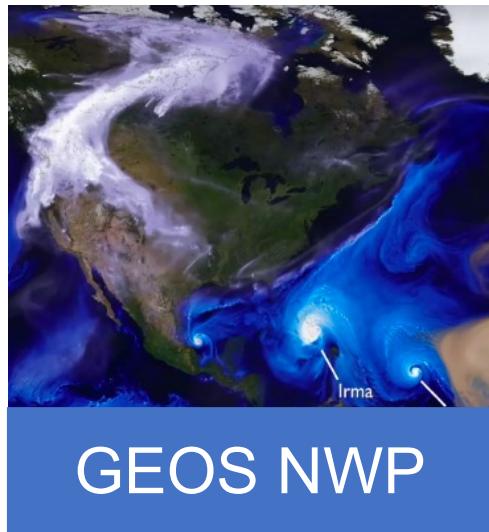
- Initialized at 12z
- 1-day meteorological replay (“analysis”)
- 5-day forecast
- 25x25 km² resolution, 72 model layers
- Chemistry: O₃, NO_x, PM, CO, VOCs, ...
- Meteorology: T, U, V, RH
- Since January 1, 2018

Emissions:

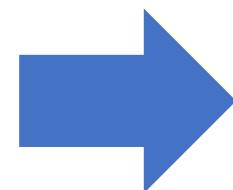
- HTAP (global bottom-up) for anthropogenic
- Near real-time fires (QFED)
- Online dust, sea salt, plant emissions



Chemistry is not cheap!



GEOS - Chem



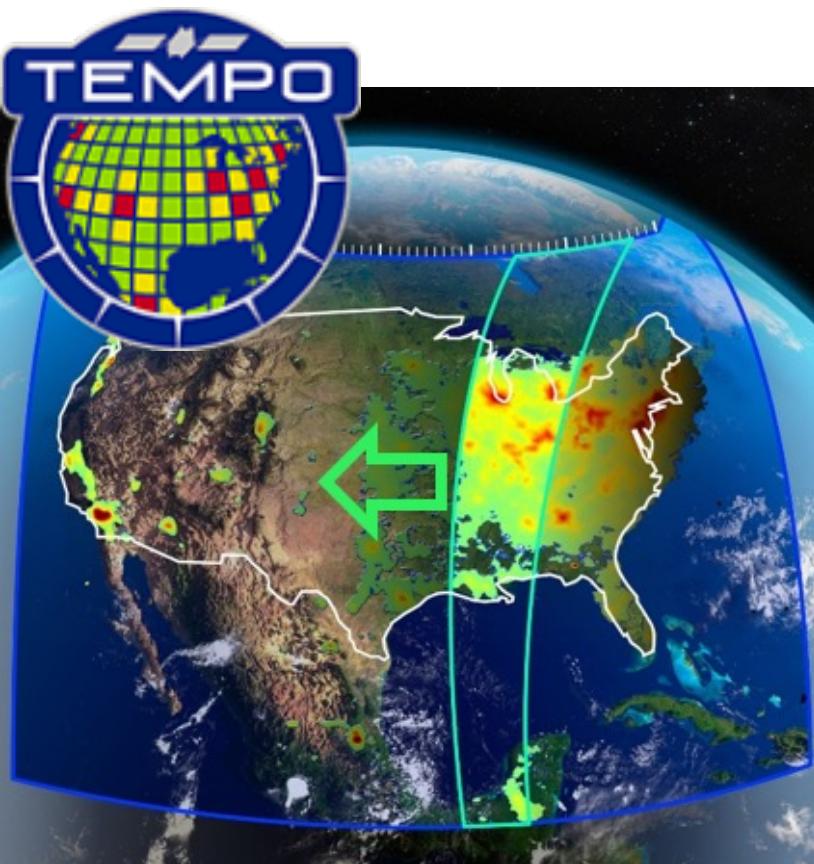
GEOS - CF

Run on **NASA's** Center for
Climate Simulation
supercomputer

- using the computing power equivalent to **3500** personal computers.

Daily atmospheric composition forecast

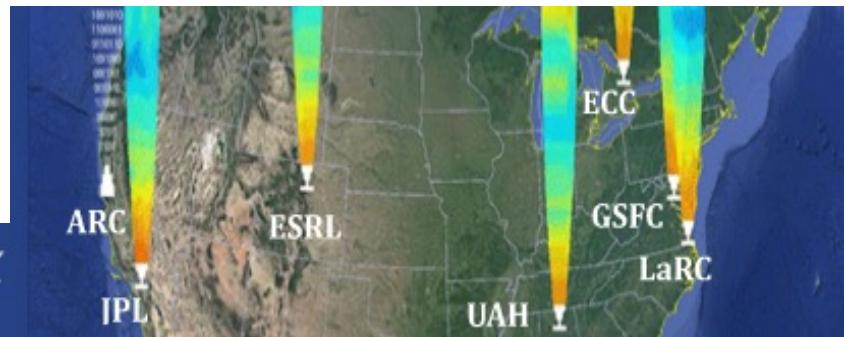
GEOS - CF



A realistic stratosphere in GEOS-CF is essential to support a broad range of NASA applications, including:

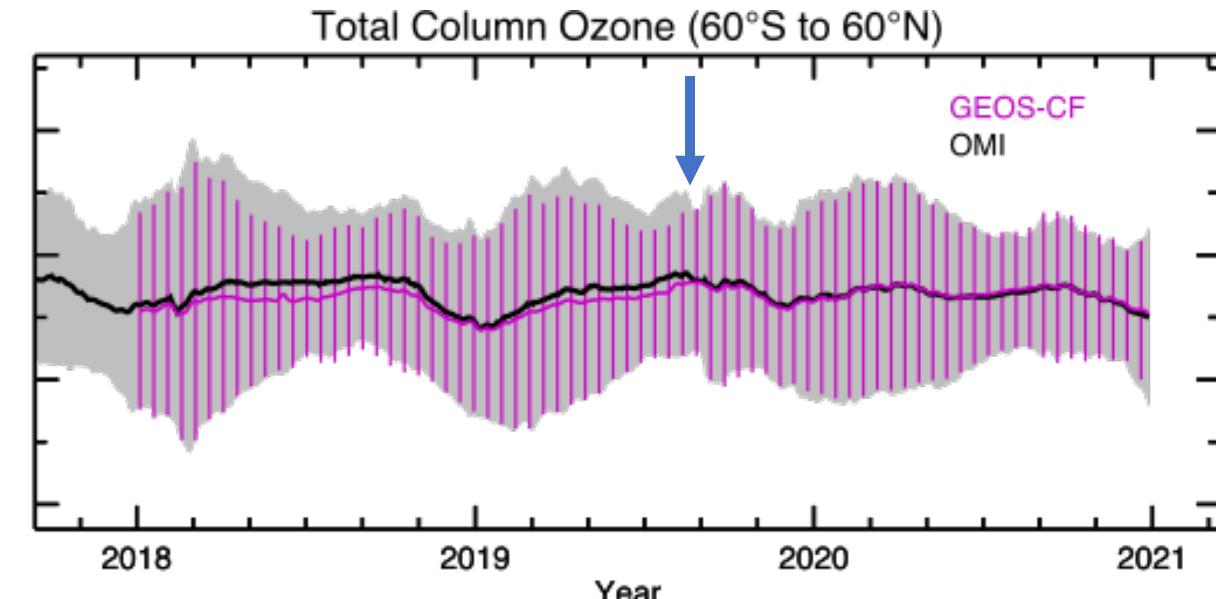
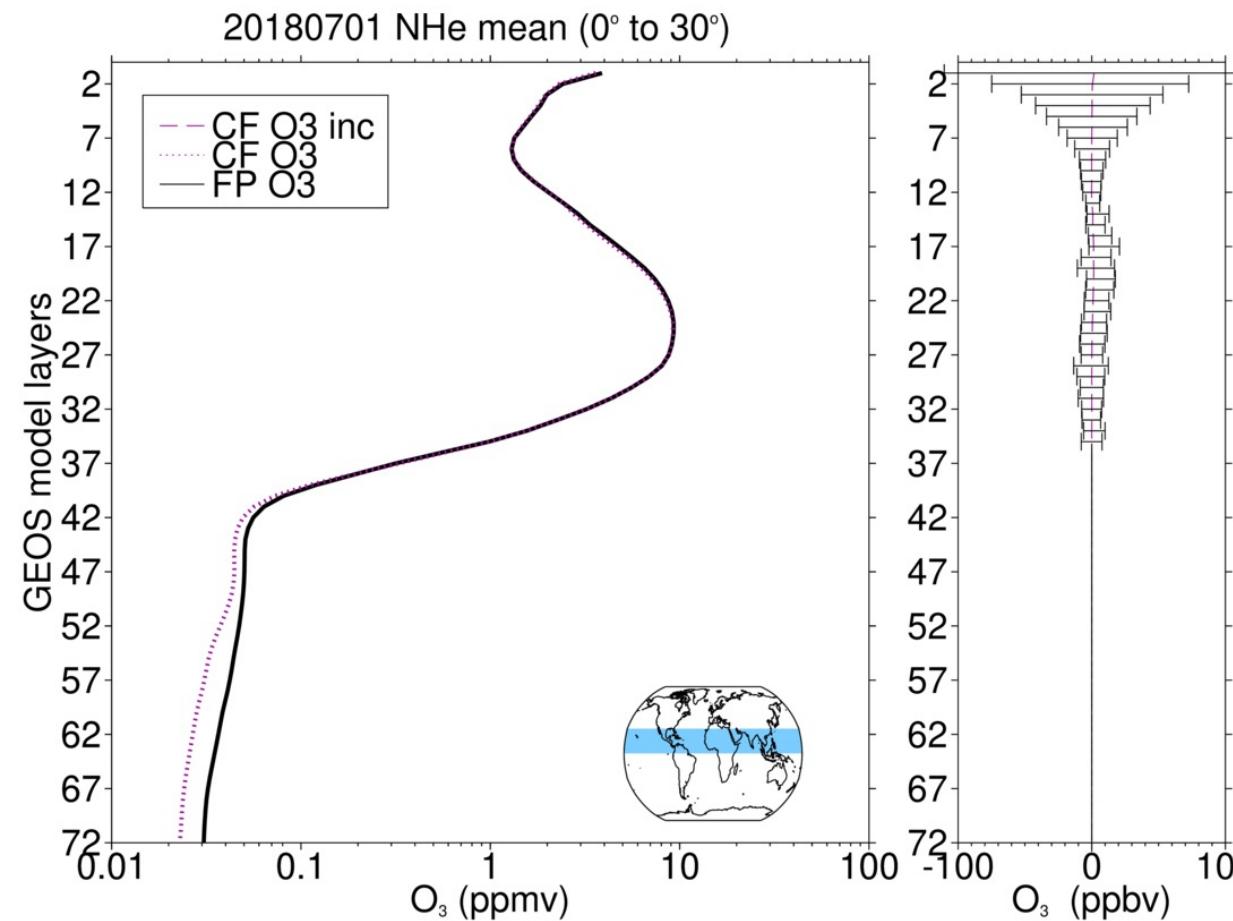


- Satellite retrievals of trace gases
- Airborne campaigns
- Stratosphere-troposphere exchange



Near-real time updates from satellite data

- GEOS-CF Stratospheric O₃ is weakly nudged to the GEOS FP assimilated O₃

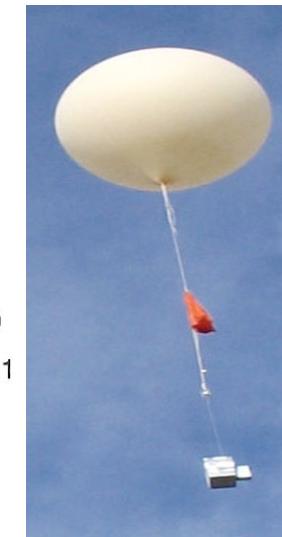
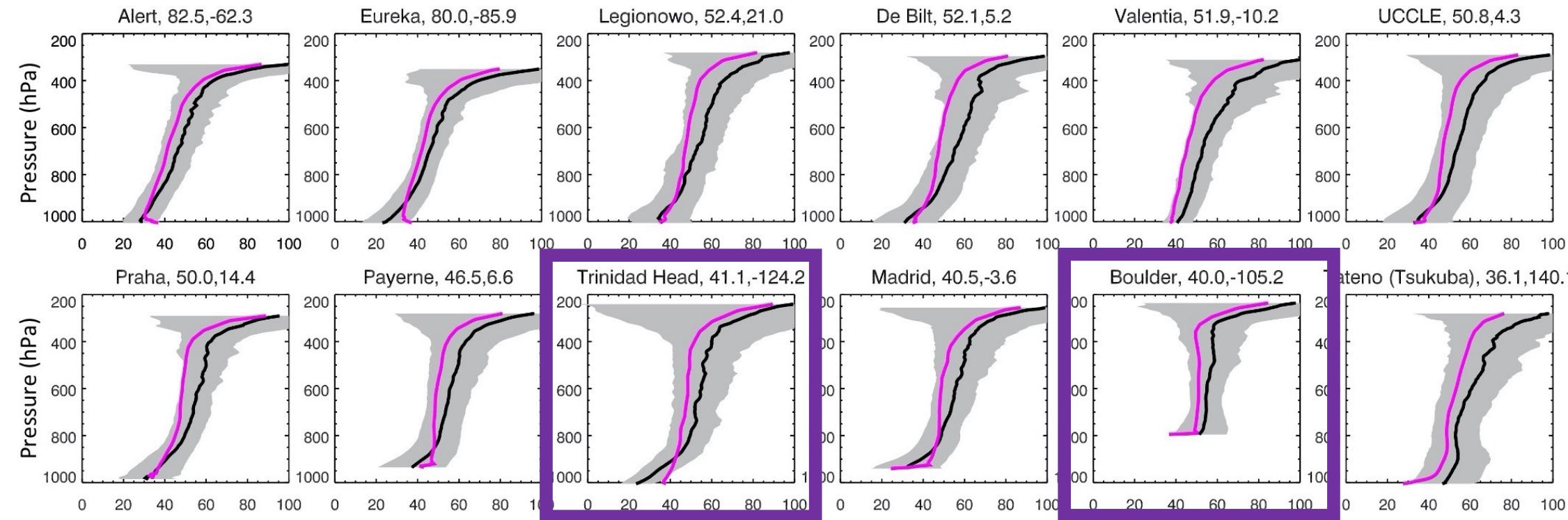


GEOS-CF captures the spread of OMI column O₃ especially after updates are made in August 2019

Knowland et al., JAMES, *under review*

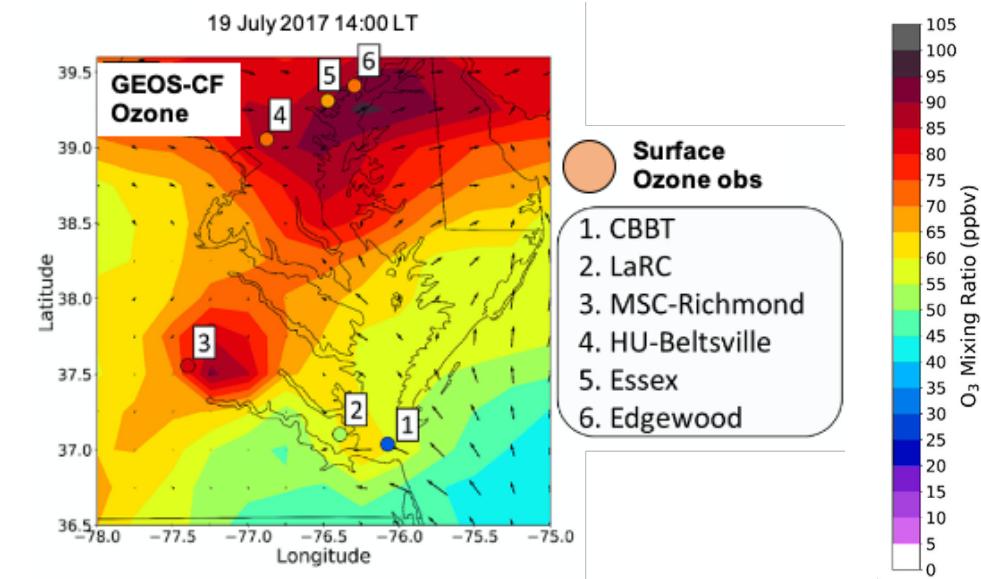
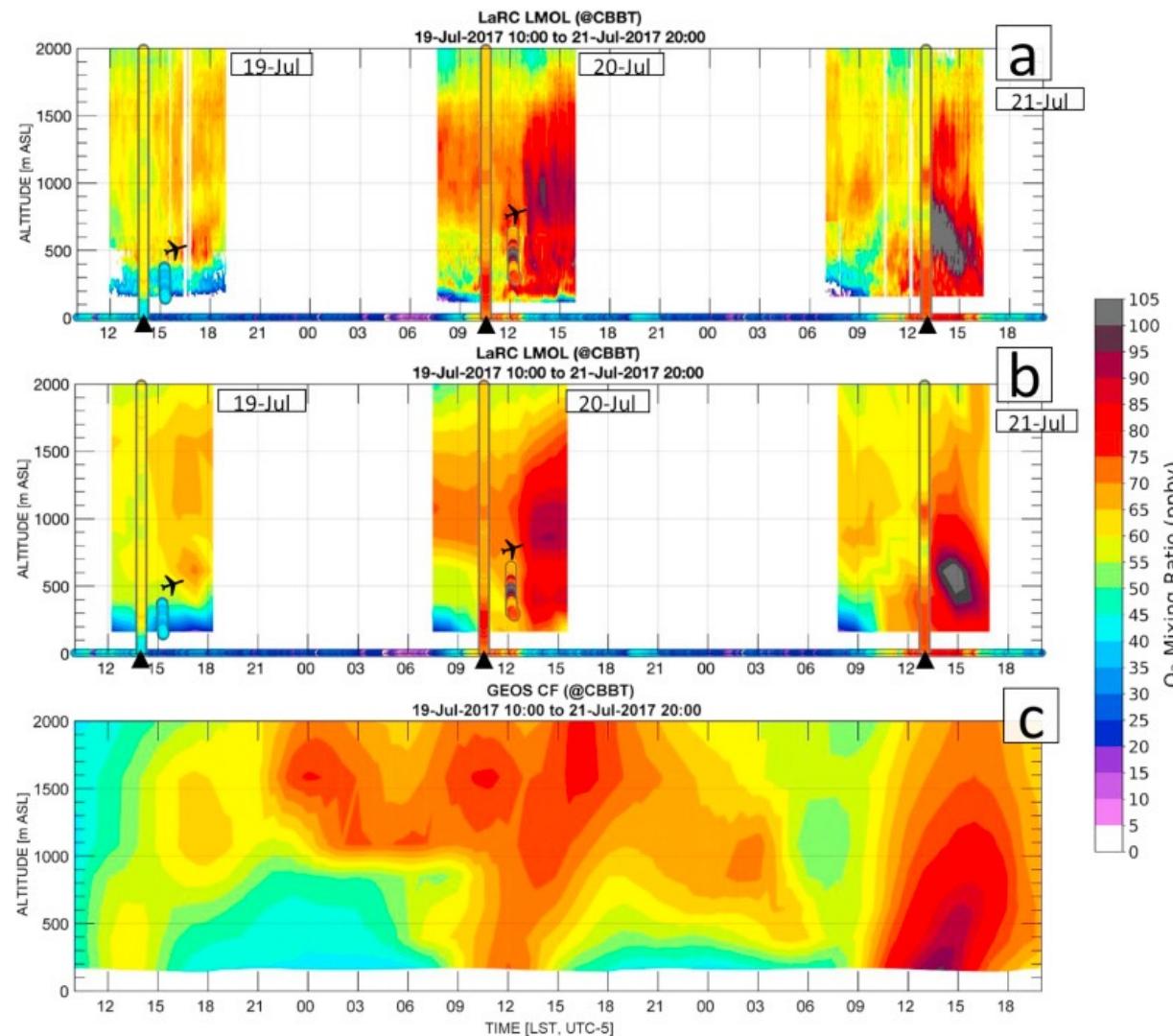
GEOS-CF ozone compares well against ozonesondes

Annual average 2018-2019



Keller et al., 2021 JAMES

GEOS-CF evaluation with NASA's OWLETS campaign observations

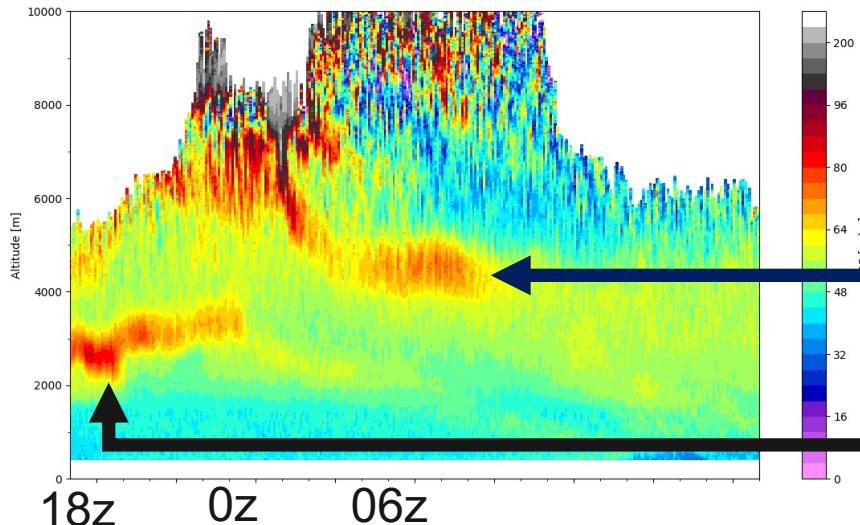


Dacic et al. (2020) used the GEOS-CF simulated ozone to put the OWLETS observations in ‘the big picture’, using the combined meteorology and chemistry to represent the synoptic conditions that lead to the observed ozone exceedances at surface observation sites.

Dacic, N. et al., 2020, *Atmos. Environ.* “Evaluation of NASA’s high-resolution global composition simulations: Understanding a pollution event in the Chesapeake Bay during the summer 2017 OWLETS campaign”

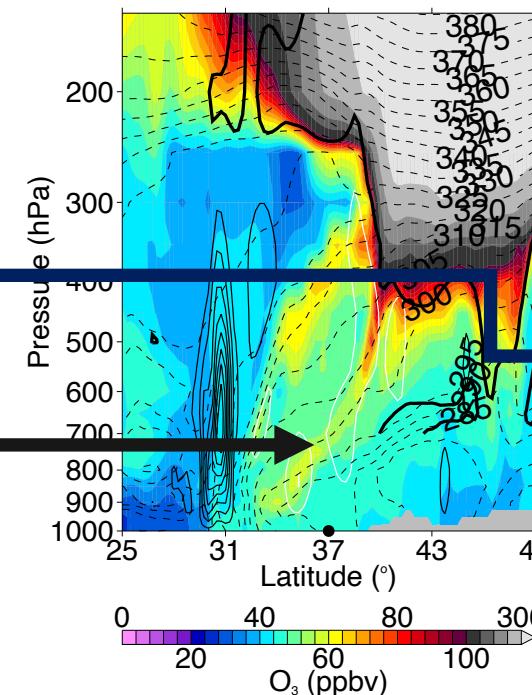
Stratosphere Troposphere Exchange

NASA LaRC Feb 13-14, 2019

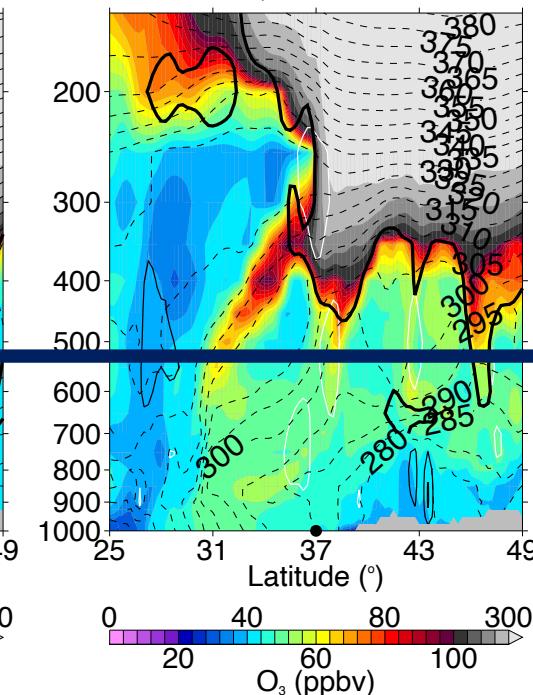


TOPAZ lidar plot courtesy of G. Gronoff

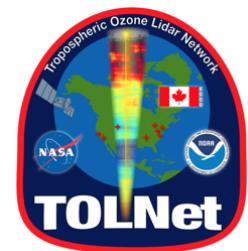
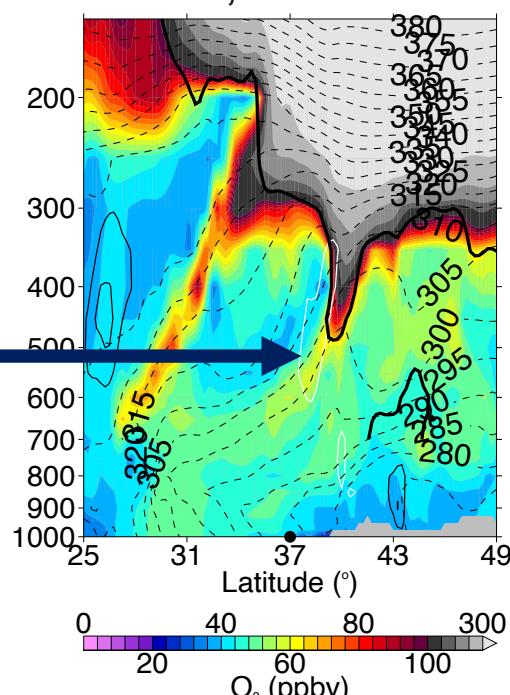
GEOS-CF
Feb 13, 2019 18z



Feb 14, 2019 00z



Feb 14, 2019 06z



Gronoff, G., T. Berkoff, K. Knowland, et al. 2021. "Case study of stratospheric Intrusion above Hampton, Virginia: lidar-observation and modeling analysis." Atmospheric Environment, 118498 [10.1016/j.atmosenv.2021.118498]



GEOS-CF are available online in near real-time

FLUID is a mobile-friendly website

[https://fluid.nccs.nasa.gov\(cf/](https://fluid.nccs.nasa.gov(cf/)

Composition Forecast

CF Datagrams

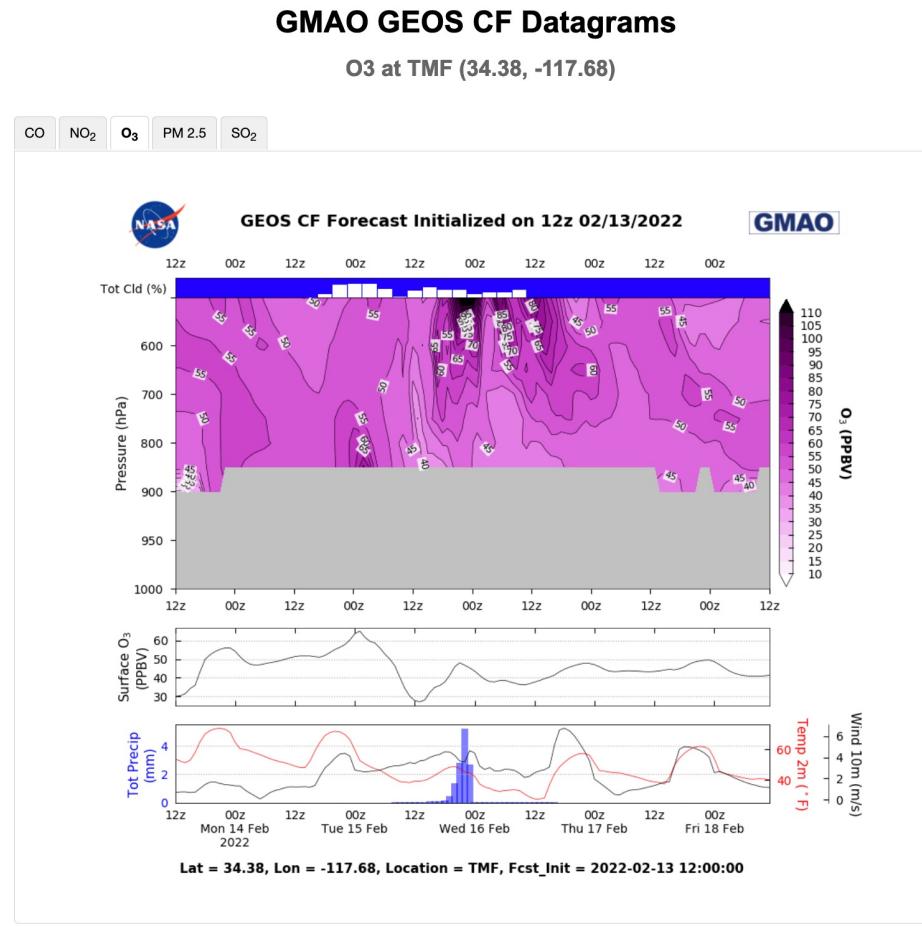
NATIONAL
Select a Station

WORLD
Select a Station

AERONET
NORTH AMERICA
TMF

MEGACITIES
Select a Station

ACTIVE CAMPAIGNS
Select a Station



GMAO

Global Modeling and Assimilation Office
gmao.gsfc.nasa.gov

https://gmao.gsfc.nasa.gov/weather_prediction/GEOS-CF/

<https://portal.nccs.nasa.gov/dashshare/gmao/geos-cf/v1/>

+ NASA HomePage
+ NASA Center for Climate Simulation

NCCS DataPortal - Dashshare

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forecast/	22-Mar-2019 13:49	-	

USA.gov Government Made Easy + Privacy Policy and Important Notices **NASA** Curator: Corey D Jones NASA Official: Dan Duffy Last Updated: 03/13/2019

<https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/>

GrADS Data Server - info for /gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1 : dds das

OPeNDAP/DODS Data URL: https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1

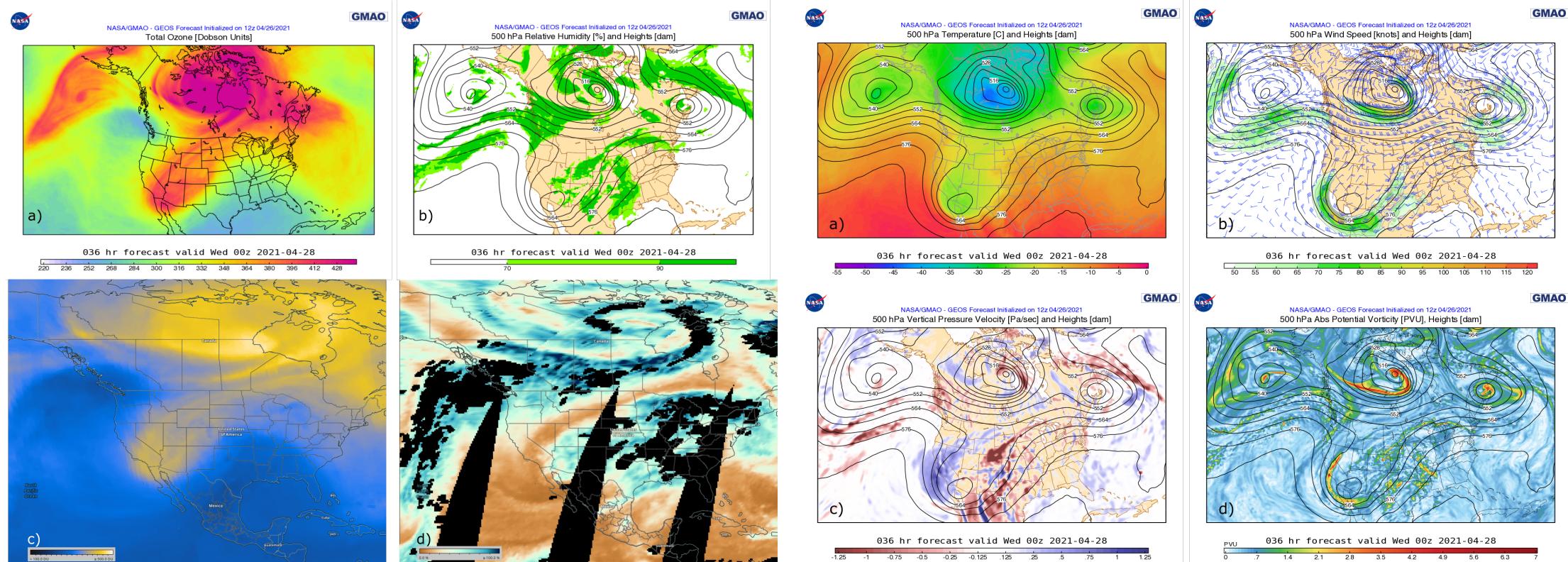
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Latitude:	-90.0000000000°N to 90.0000000000°N (721 points, avg. res. 0.25°)
Altitude:	72.0000000000 to 72.0000000000 (1 points)
Time:	00:30Z01JAN2018 to 11:30Z31OCT2019 (16044 points, avg. res. 0.042 days)
Variables:	(total of 52)
xyle	xylene (c8h10, mw = 106.16 g mol-1) volume mixing ratio dry air
dst2	dust aerosol, reff = 1.4 microns (mw = 29.00 g mol-1) volume mixing ratio dry air
hno4	peroxynitric acid (hno4, mw = 79.00 g mol-1) volume mixing ratio dry air
pm25su_rh35_gcc	sulfate_particulate_matter_with_diameter_below_2.5_um_rh_35

k.e.knowland@nasa.gov

Duncan et al. (2021) GeoHealth

Section 3.3.3 Stratospheric influence on Surface AQ

- Description on how to use GMAO's FLUID and NASA Worldview website to diagnose Stratospheric Intrusions using combination of GEOS products and satellite observations

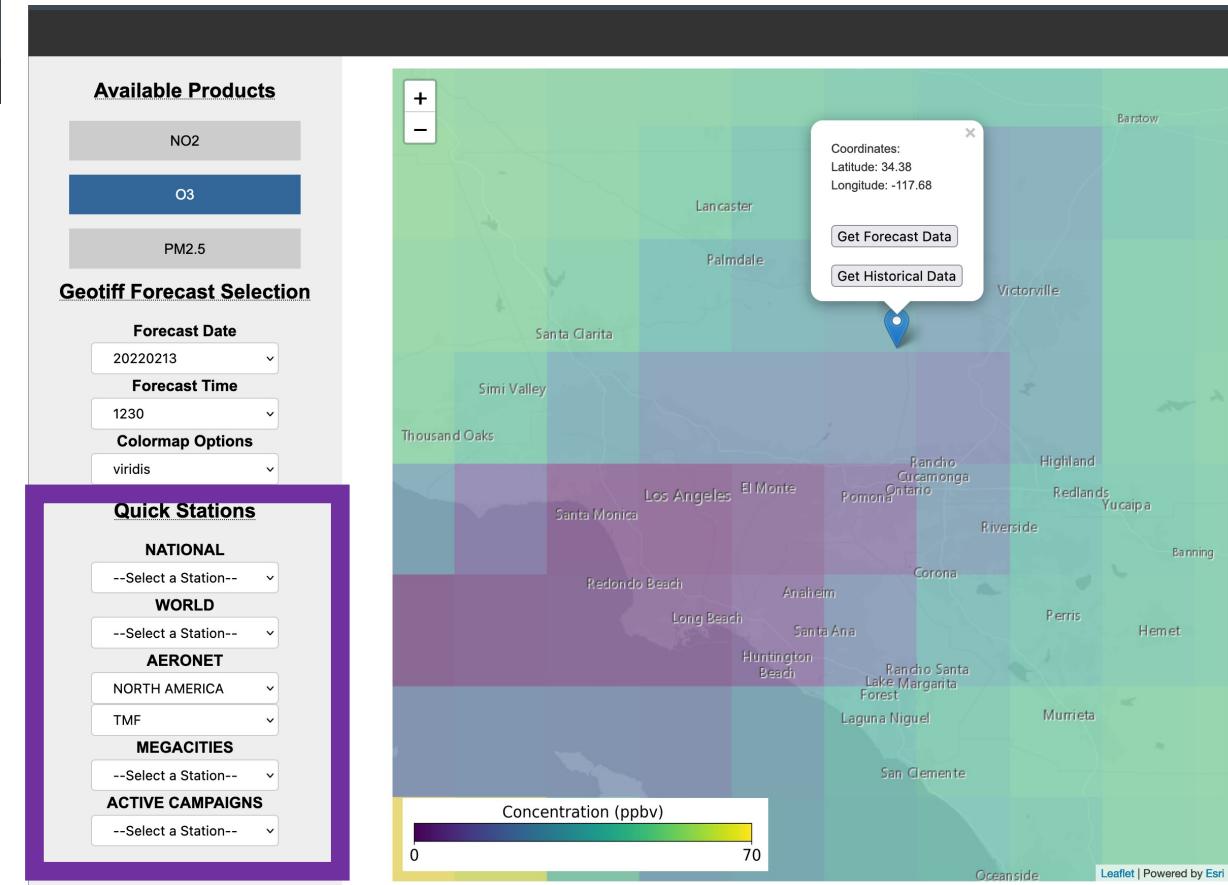
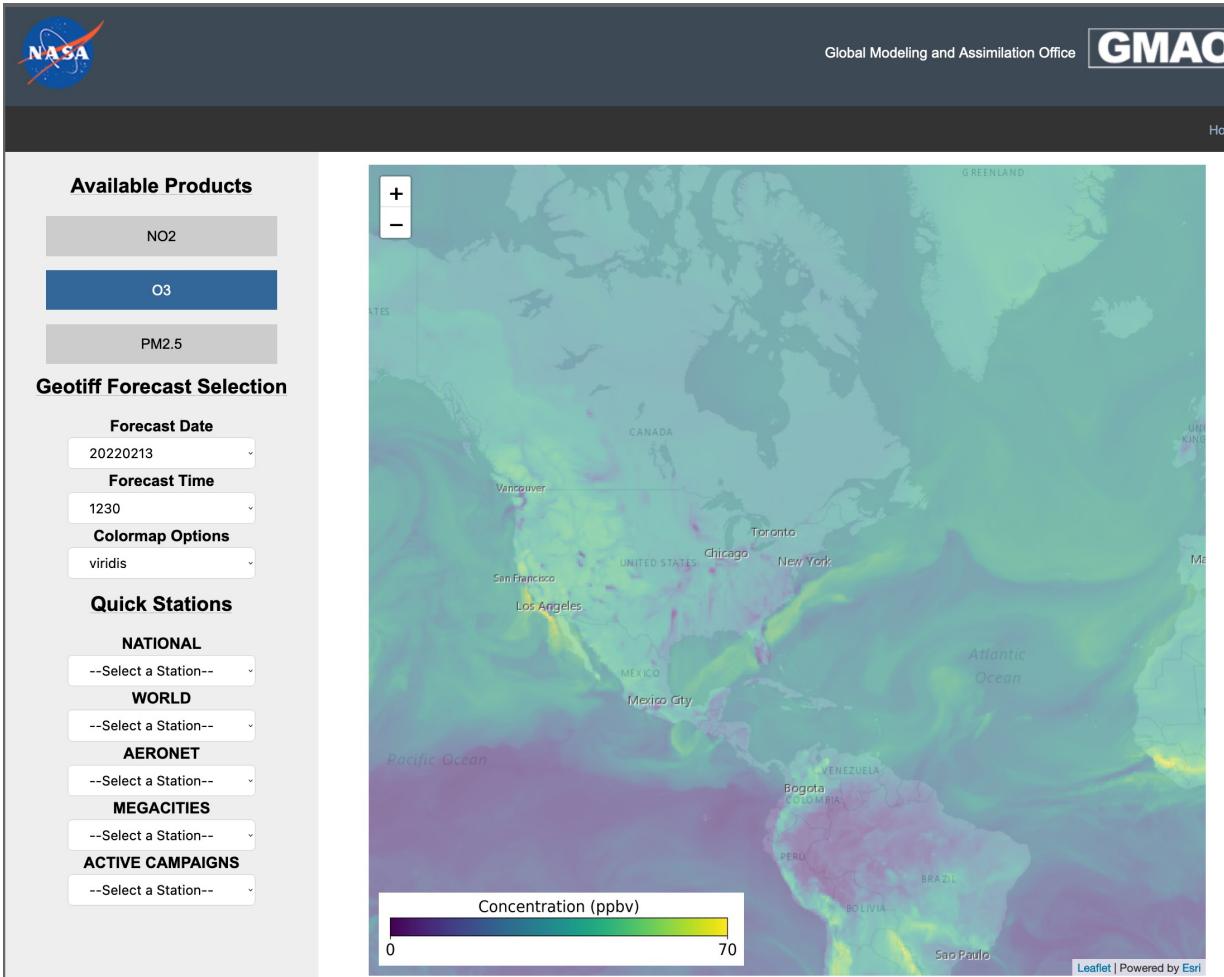


Duncan, B. N., C. A. Malings, K. E. Knowland, et al. 2021. "Augmenting the Standard Operating Procedures of Health and Air Quality Stakeholders With NASA Resources." *GeoHealth*, 5 (9): [10.1029/2021gh000451]

Emerging FLUID Features *in Development*

Capability to zoom in and select data for any grid box

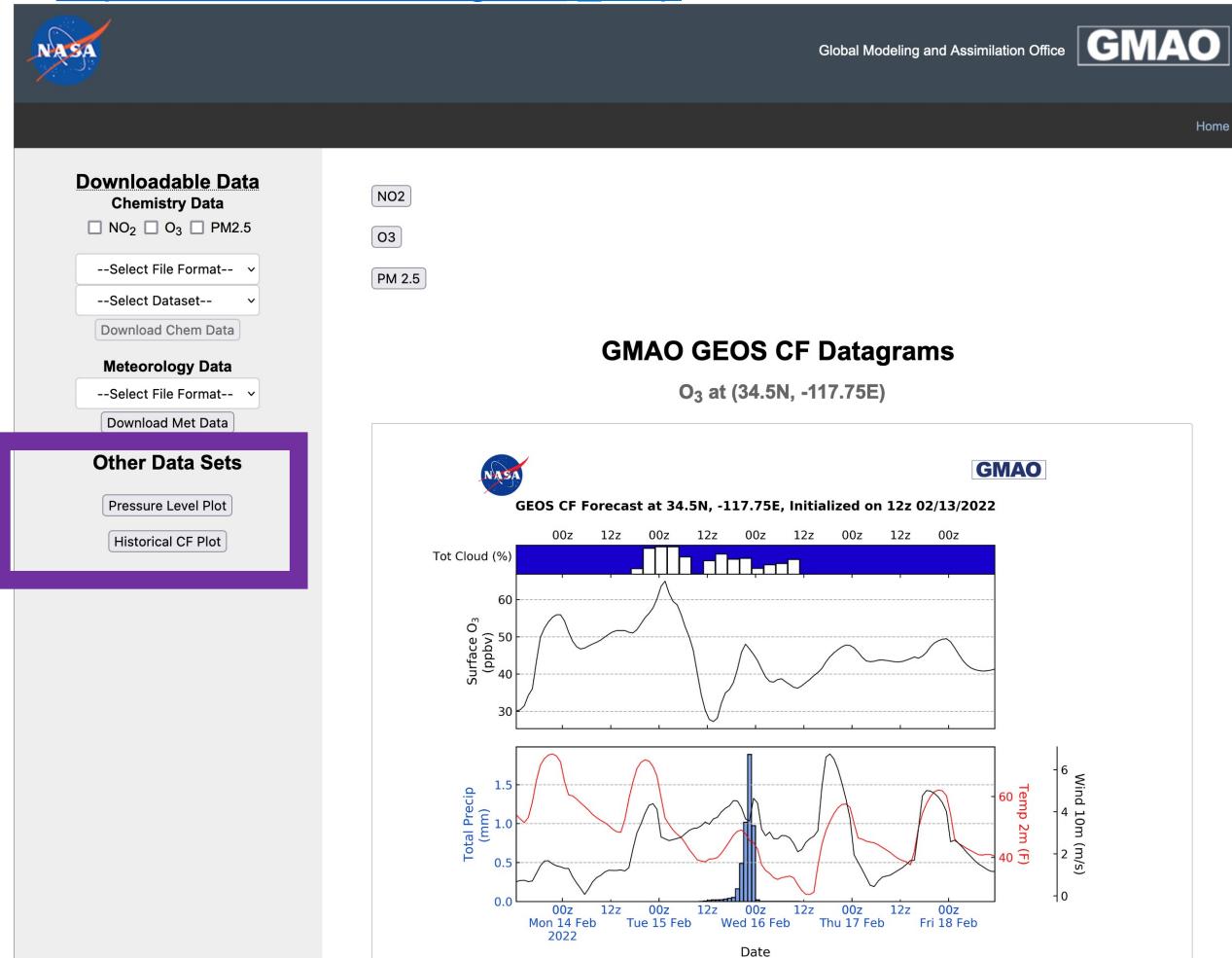
https://fluid.nccs.nasa.gov/cf_map



Emerging FLUID Features *in Development*

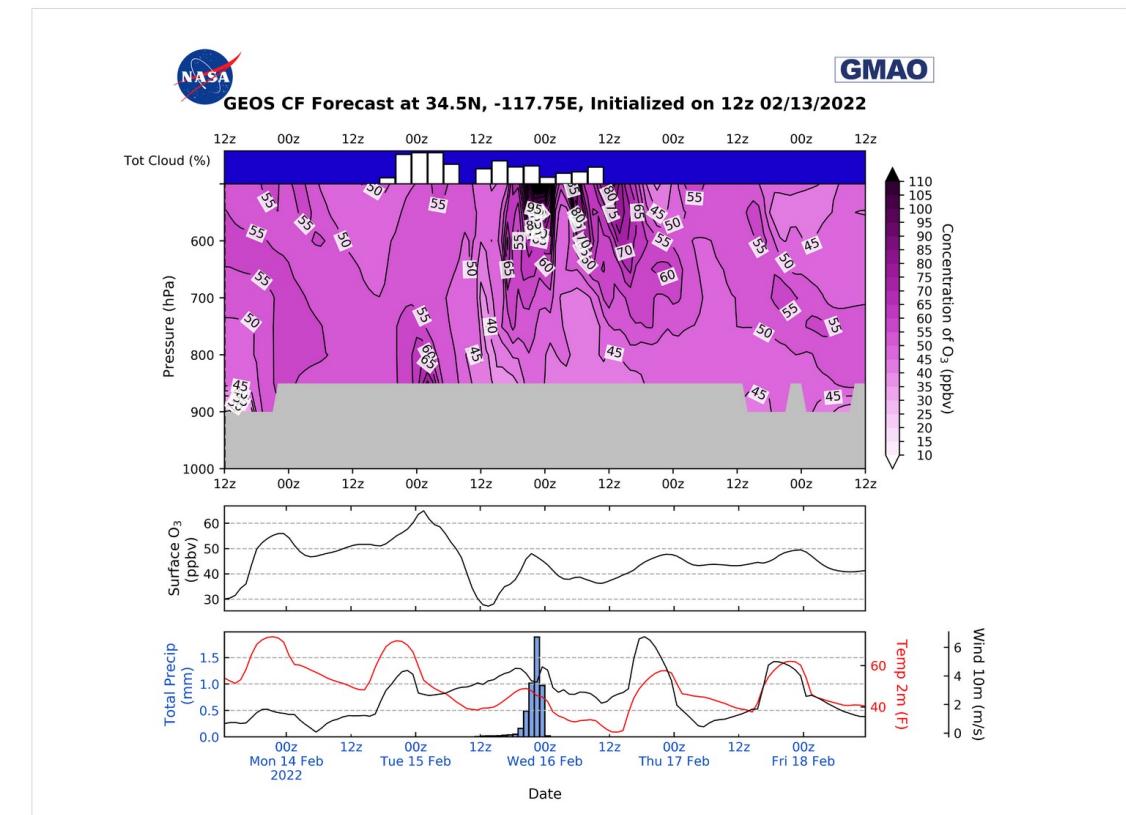
Capability to zoom in and select data for any grid box

https://fluid.nccs.nasa.gov/cf_map



GMAO GEOS CF DataGrams

O₃ at (34.5N, -117.75E)



Summary

GEOS-CF produces daily global air quality forecasts at 25km (16 miles) horizontal resolution since 1 January 2018

- AQ maps and data access
fluid.nccs.nasa.gov/cf
- Forecast anywhere in the world
fluid.nccs.nasa.gov/cf_map

